Geobodies Stochastic Analysis for Geological Model Parameter Inference

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Introduction

It is sometimes difficult to infer the input parameters of a geological model. For example, when variogram based simulation methods like SIS, Truncated Gaussian or Truncated Pluri-Gaussian facies simulation methods are used, inferring the facies horizontal variogram range may be very difficult in heterogeneous contexts, due to interwell spacing.

An indirect method for inferring input parameters, based on geobodies characteristics analysis, can be used in such difficult cases. The method also allows selecting realizations of a geological model according to properties that are critical in flow simulations.

→ Geobodies analysis allows getting geomodel input parameters consistent with dynamic data

Geological model characterization by geobodies

Geobodies definition

- Set of geomodel cells with same property and one face in common (connected component)

Geological model characterization

- Geobodies corresponding to permeable pathways can be easily calculated from realizations of a geological model.
- The analysis of the intersection between such permeable pathways and perforations allows checking model consistency with dynamic data.

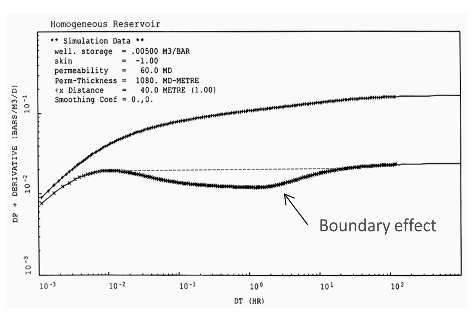
→ Permeable pathways distribution and size depends on geomodel parameters

Stochastic analysis for model parameters inference and selection of realizations

1. Detailed Methodology

Step1: identification of hydraulic connections between wells

- Analysis of well tests, production data, pressure for detecting the presence of permeable pathways between wells.
- Definition of the connection criterion:
  - facies or facies group;
  - Permeability threshold, which value depends on the geological environment and on the fluid.



Step2: Definition of geomodel input parameters range of variation

- For each geostatistical simulation input parameter, a realistic range of variation is defined by the geologist. For example, several possible facies variogram ranges and/or permeable facies proportions can be defined for SIS or PGS facies simulation methods.

Step 3: calculation of geobodies

- Geobodies corresponding to permeable pathways are calculated in each realization of the geological model.
- Connected components calculation is based on selected geological facies or on sets defined by a threshold on absolute permeability.
- The analysis of the intersection between such permeable pathways and perforations allows checking model consistency with dynamic data.

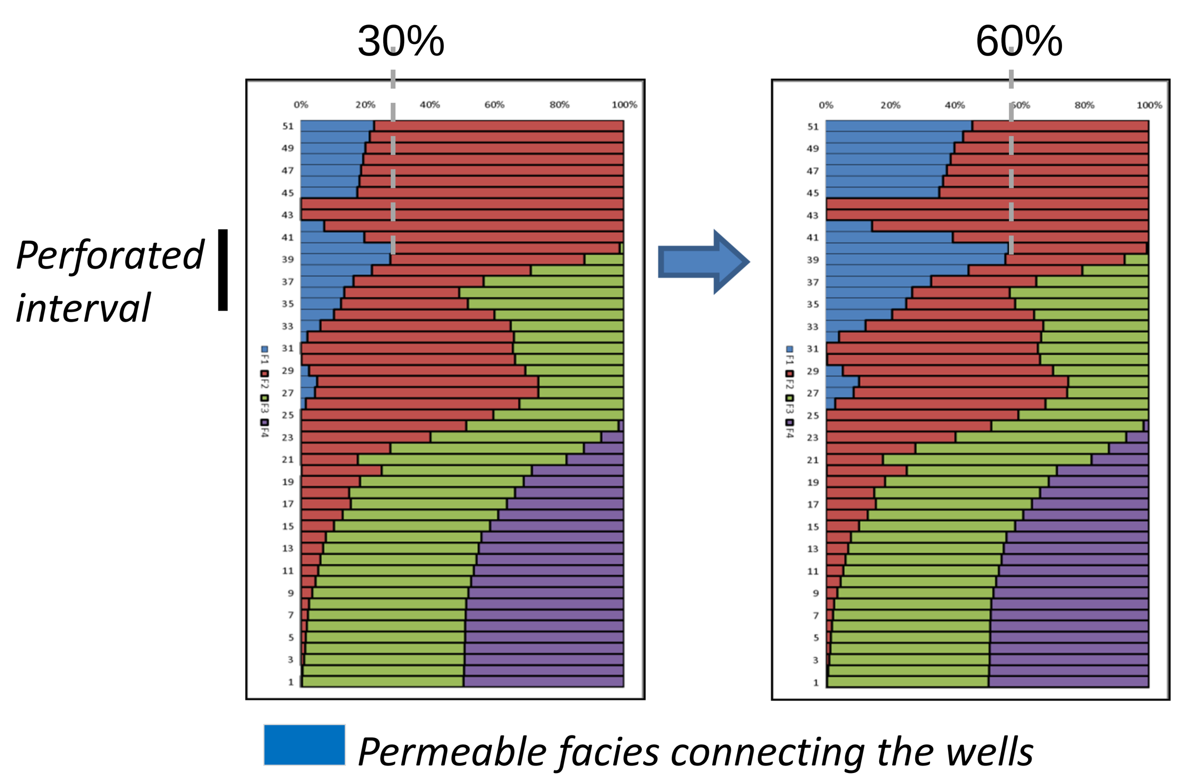
→ The selected values of model input parameters are the ones which ensure that the wells which have been observed as connected are connected in the model, in all the realizations.

2. Example with Pluri-Gaussian Simulations: variation of input parameters

Two input parameters have been considered simultaneously:

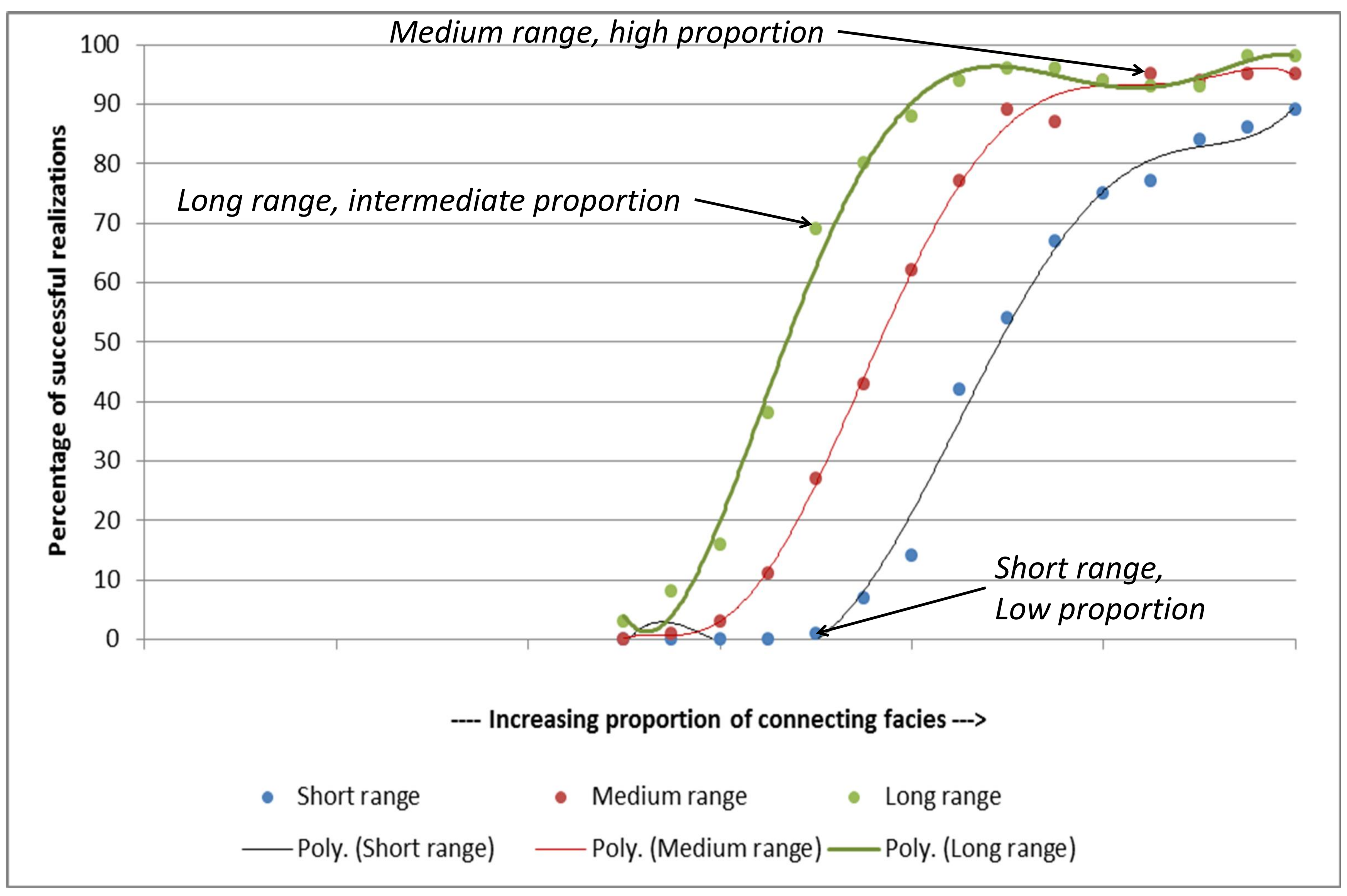
- The proportion of the permeable facies which establishes the connection between wells. In the example, it varies from about 30% to about 60% at the perforations level in the two wells.
- The facies variogram range.

For each parameter, several values within the range of variation are considered and all the possible combinations of proportion and variogram range are tested. For each combination of input parameters, 100 stochastic realizations have been calculated.



Extreme cases for testing sensitivity to facies proportion

3. Example with Pluri-Gaussian Simulations: Stochastic analysis and geostatistical simulations input parameters inference



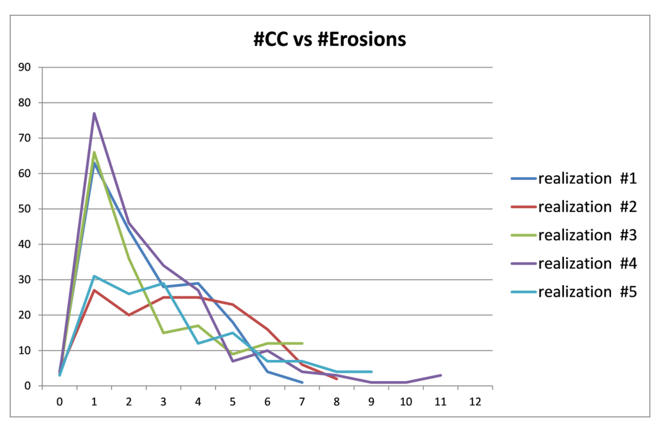
Sensitivity analysis results

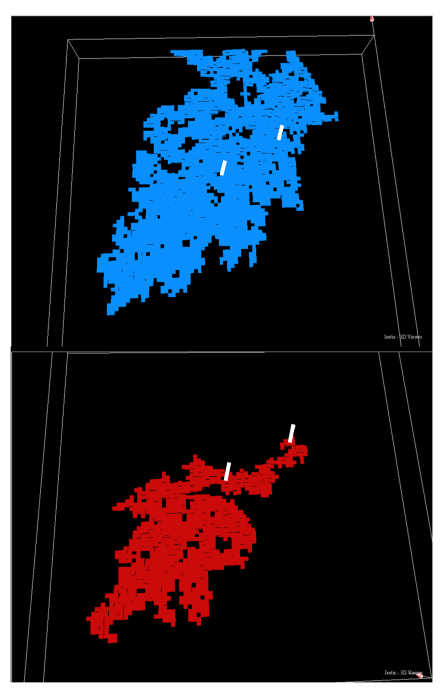
The percentage of realizations in which the connected wells are linked by a permeable pathway depends on the permeable facies proportion and on the variogram range:

- Low proportion, short range – low percentage of successful realizations.
- High proportion, long range – very high percentage of successful realizations.
- Intermediate configurations – fast increase of successful realizations percentage.

The size and shape of connecting geobodies can be characterized

- Geobody volume and regularity impact flow performance.
- Several metrics help characterizing and sorting the successful realizations, such as the number of geobodies after successive erosions.





→The most accurate values of proportion and variogram range correspond to the combination of values leading to more than 95% of successful realizations with a maximum of connecting geobodies with the adequate shape.

Conclusions

- Analyzing permeable pathways calculated from connected components in many realizations of a geological model, not in a single realization only, allows inferring model input parameters when it is difficult to do with standard methods. It also provides some ways of forcing the model to honor properties which are critical for production history match.
- Such an analysis is based on post-processing calculations. Therefore it can be applied with any geostatistical simulation method. It is easy to implement in practice, as it can be made with commercial software packages.
- It encourages geologists and reservoir engineers to communicate and preserves the ability to perform rigorous uncertainty analysis.

All results obtained using ISATIS software, developed by Geovariances. For more information: http://www.geovariances.com